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LOKI WIND CORRECTION COMPUTER SYSTEM

QUARTERLY PROGRESS REPORT

For Period October 1, 1953 through December 31, 1953

Contract DA-04-495-Ord-352

Sub-RAD Order No. ORDTU 2-1106-7

Ordnance Project No. TU 2-1012

ALTADENA, CALIFORNIA

PART I

LOKI WIND CORRECTION COMPUTER SYSTEM

BY

John F. Moss, Jr.

PART II

ANALYSIS OF BALLOON BORNE HOT WIRE ANEMOMETER DATA FOR LOKI

BY

Bernard Helfand

Quarterly Progress Report
For period October 1, 1953 through December 31, 1953

March 1, 1954

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Abstract

PART I

This report deals with the circuitry of the experimental wind correction computer and shows the physical arrangement of the electronic units, electromechanical units and associated hardware.

PART II

A statistical analysis is presented for the 1000-ft. wind profiles obtained in the balloon-borne hot wire anemometer program. A total of 520 correlation coefficients were computed for comparison of winds with burnout deviation. The wind parameters are anemometer height or height combination and time evaluation. The correlation coefficients for each time and height combination are tabulated and their significance discussed.

PART I

Introduction

The operating principle of the experimental wind correction computer has been discussed in previous reports (Refs. 1 and 2). The present status of the development of the computer is as follows. All of the electronic circuits have been designed, assembled, and rack mounted in their final configuration, the characteristics of servo systems have been individually determined, and the assembly of the electromechanical portion of the computer is complete with the exception of four servo motors that will soon be delivered.

The integration of the various parts of the computer into its aggregate form is now in process. Details of the circuitry and arrangement of components will be discussed here.

Physical Layout

The experimental wind correction computer will be housed in two weather-proof enclosures that provide for standard rack mounting. A multiple channel pen recorder will be used in conjunction with the computer to record its transient characteristics and to indicate the frequency spectra of the wind corrections when the anemometer is exposed to real winds. The anemometer that supplies the wind information for the computer has been described in a previous report (Ref. 3). Its relationship to the two enclosures and the recorder is shown in Fig. 1. One of the two enclosures contains the 3000-cycle oscillator and the DC voltage supplies, the other contains the computer which is divided into four units as shown in the figure.

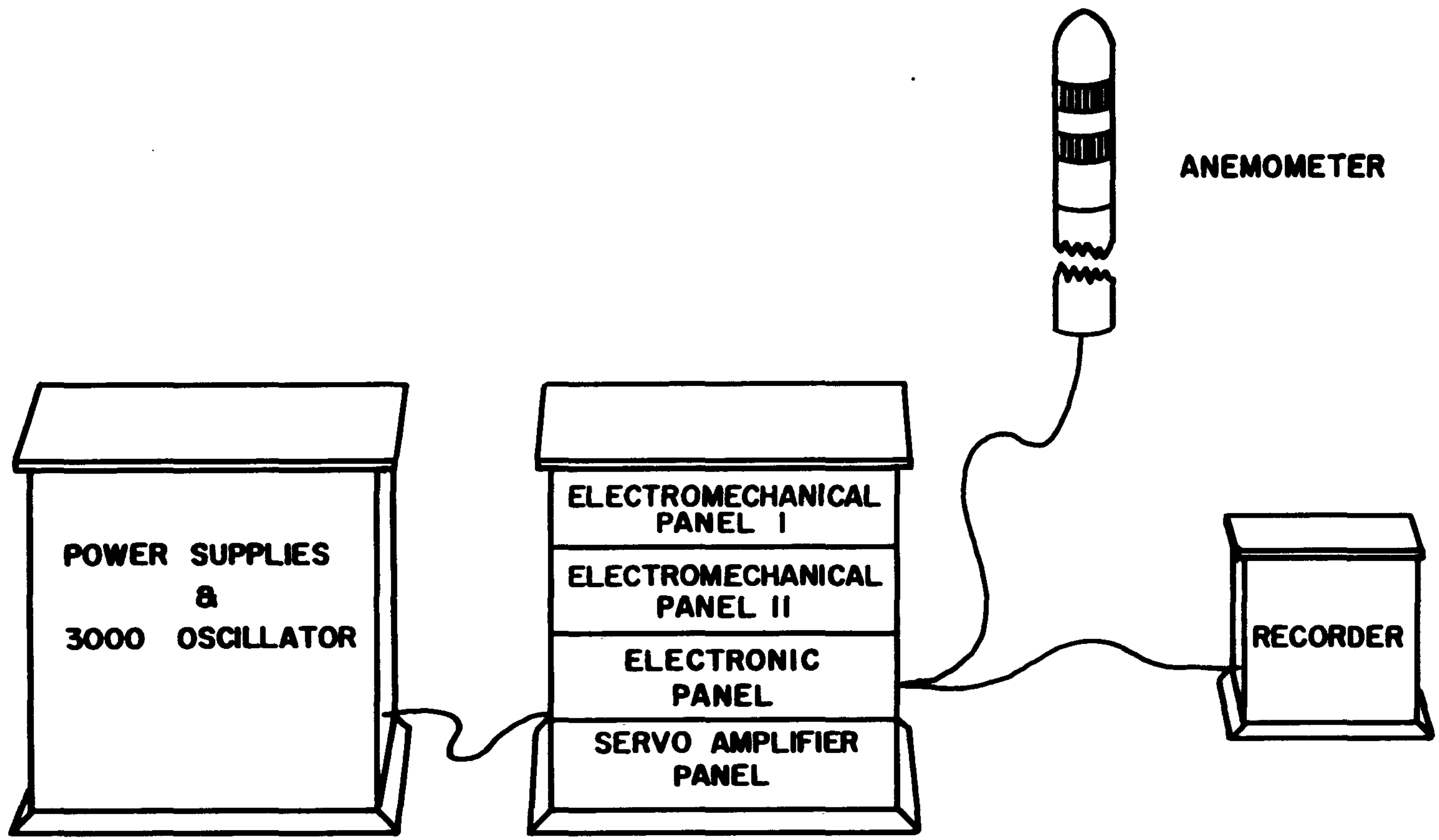


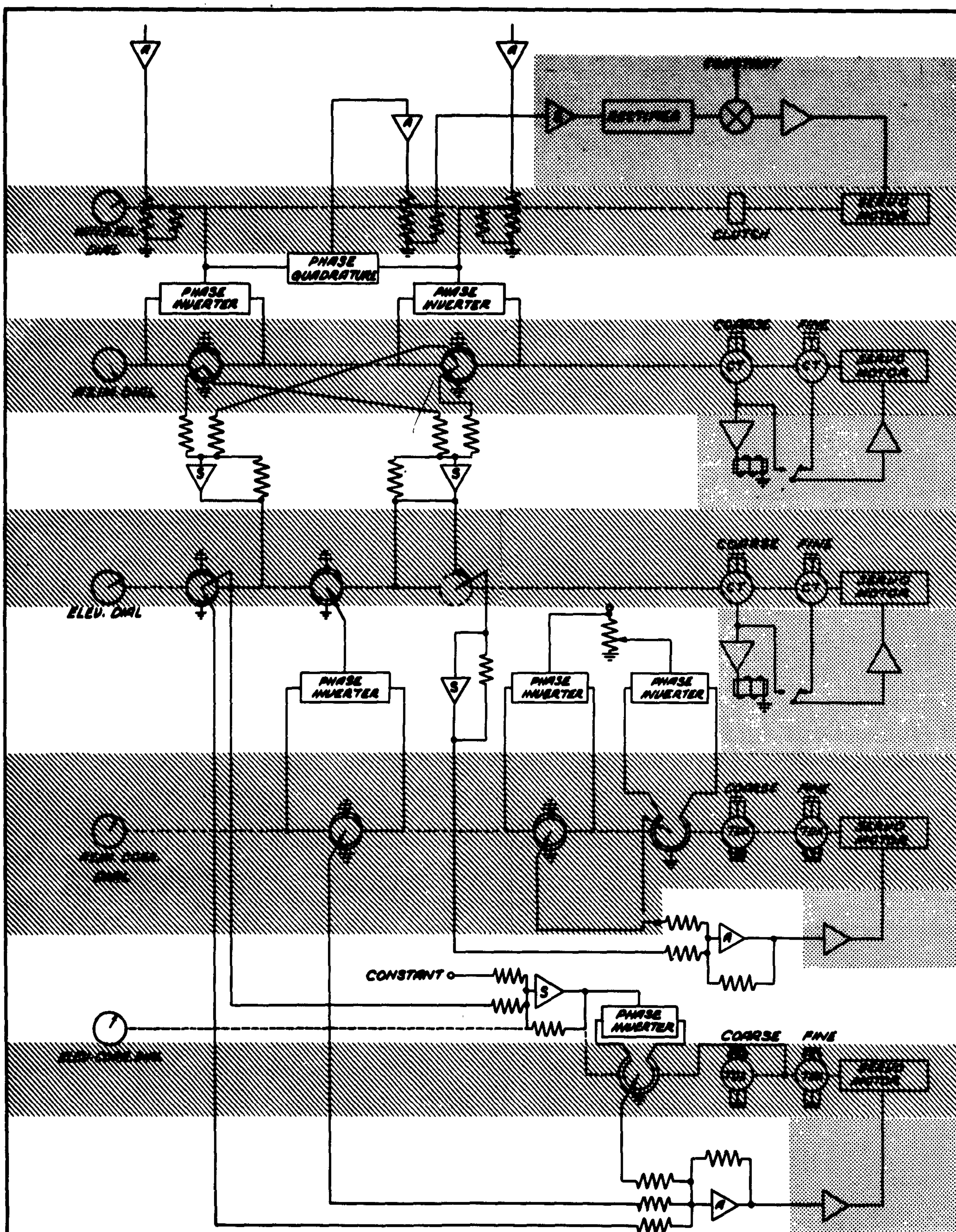
FIG. 1 PHYSICAL LAYOUT

The two upper units contain the electromechanical section of the computer. The third unit contains the electronic section and the bottom unit contains the servo amplifier section. A block diagram is shown in Fig. 2 which defines the electromechanical, electronic, and servo amplifier sections. The layout of the electronic and servo amplifier sections will be described in further detail in this report.

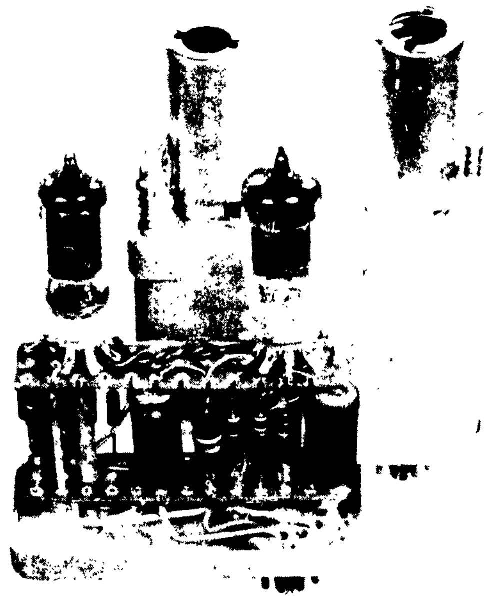
Electronic Components

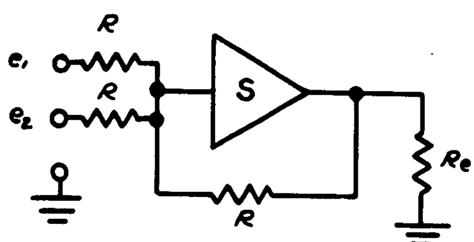
The components to be described in this section are the summing amplifiers, high gain amplifiers, and the phase inverters, as they are used in the computer.

The summing amplifiers shown in Fig. 3 are plug-in units used in the computer where indicated in Fig. 2. The amplifier is stable for 100% negative feedback where the open loop gain ranges from 65 to 75 db depending upon the load. The frequency response curves are shown in Fig. 4a. To increase the number of roles which can be filled by the summing amplifier, the feedback resistors are located external to the plug-in unit. The amplifier consists of a pentode stage followed by two triode stages. The RC networks in the plate circuits of the first two circuits provide the high frequency stabilization and the coupling between the 2nd and 3rd stages attenuates the low frequencies so that the desired response is obtained. The positive feedback between the cathodes of the first two stages permits the deletion of cathode bypass capacitors without loss of gain or stability. The accuracy of the summing amplifier is determined by the 1% feedback resistors. Dependence of operating characteristics upon component values is reduced a thousand-fold by the feedback.



COMPUTER BLOCK DIAGRAM FIG. 2





TYPICAL CIRCUITRY USING SUMMING AMPLIFIER

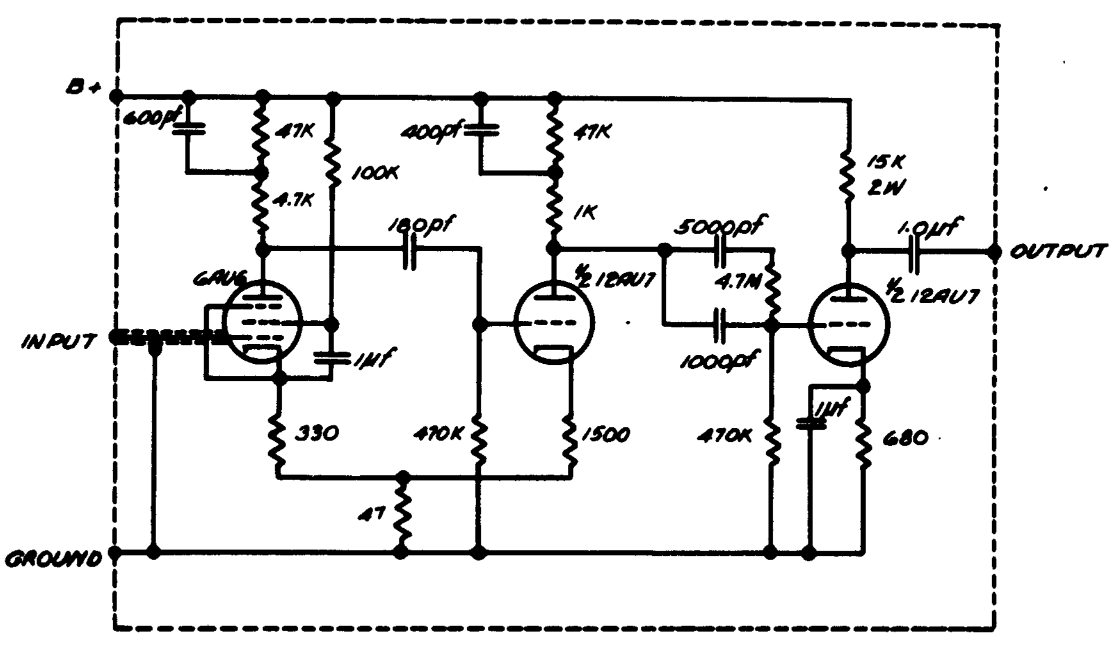
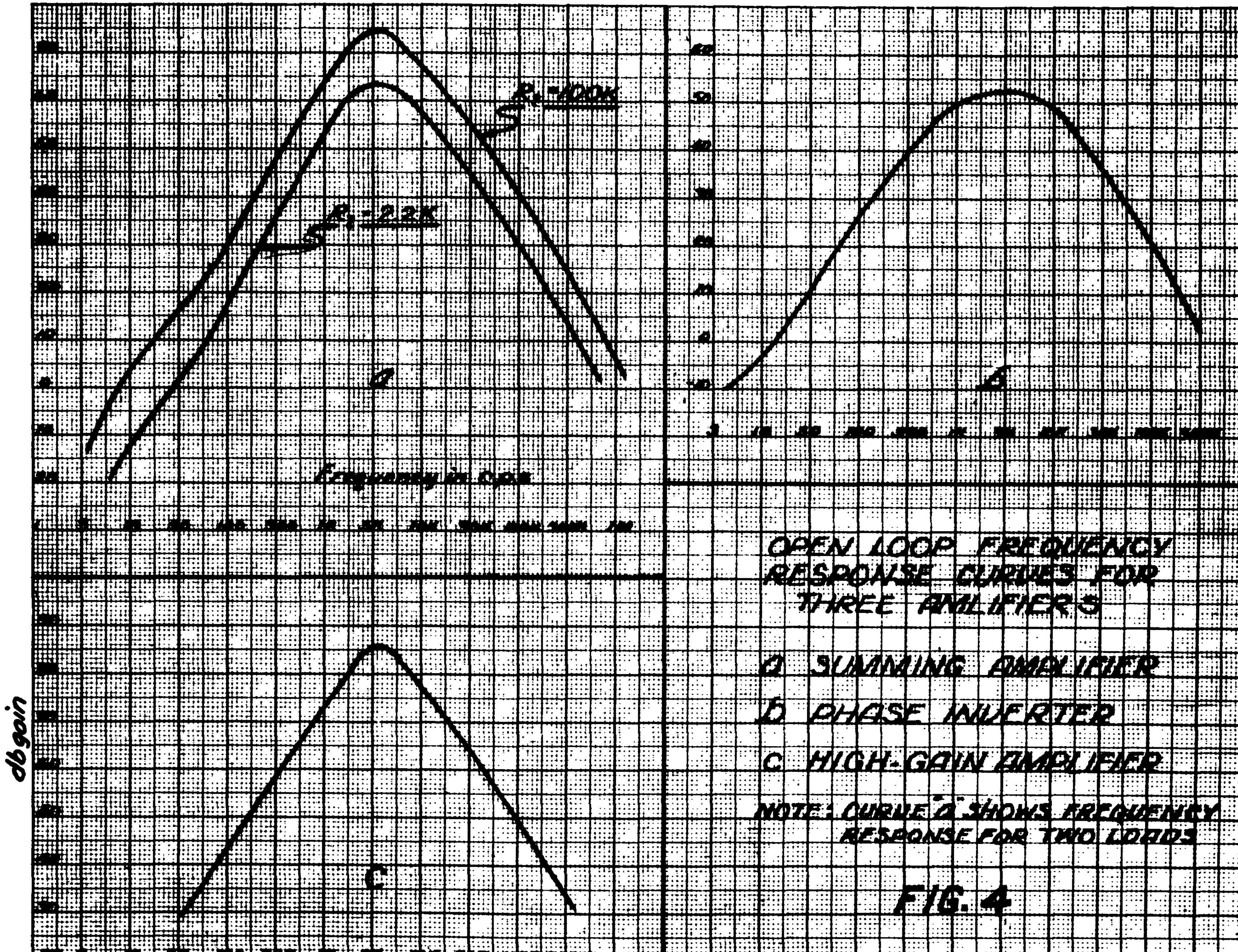


FIG.3 SUMMING AMPLIFIER



OPEN LOOP FREQUENCY RESPONSE CURVES FOR THREE AMLIFIERS

a SUMMING AMPLIFIER

b PHASE INVERTER

C HIGH-GAIN AMPLIFIER

NOTE: CURVE "a" SHOWS FREQUENCY RESPONSE FOR TWO LOADS

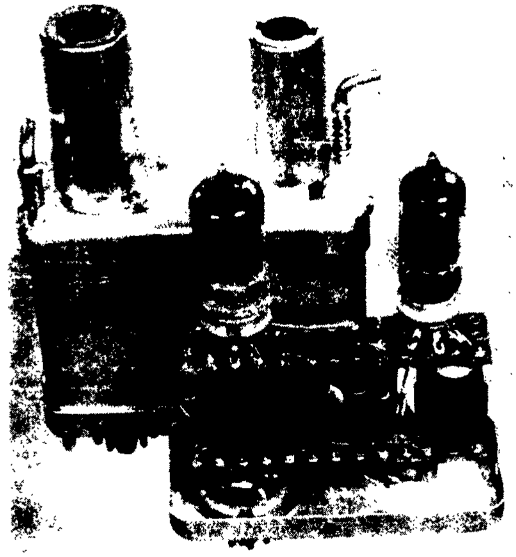
FIG. 4

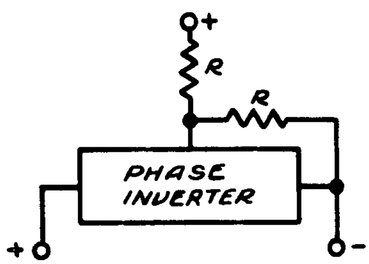
The phase inverter is a plug-in unit very similar to the summing amplifier with the exception of the last stage where the inversion is effected. The frequency response curves are shown in Fig. 4b and the schematic of the phase inverter is shown in Fig. 5. The RC networks are used to shape the frequency response curve to a stable configuration for feedback purposes. About 50 db feedback is applied to the input grid from the plate of the third stage, thus stabilizing this output about three hundred-fold. An external potentiometer is used to balance the magnitude of the cathode output with that of the plate. The overall gain is held to unity by 1% resistors in most applications within the computer.

The high-gain amplifier has an open loop gain of about 86 db and is stable for feedback up to 65 db; however, as it is used within the computer, no more than 60 db is used to stabilize the gain. This amplifier is a plug-in unit with two pentodes followed by two triodes. The circuit is shown in Fig. 6 and its frequency characteristics are shown in Fig. 4c. The circuit is similar to that of the summing amplifier but it has an additional stage of amplification. The use of this amplifier within the computer is shown in the Computer Block Diagram, Fig. 2.

Servo Systems

The Servo System has been divided into two physical units, the Servo Amplifier Panel and the Electromechanical section. The Block Diagram (Fig. 2) indicates this division.





TYPICAL CIRCUITRY USING PHASE INVERTER

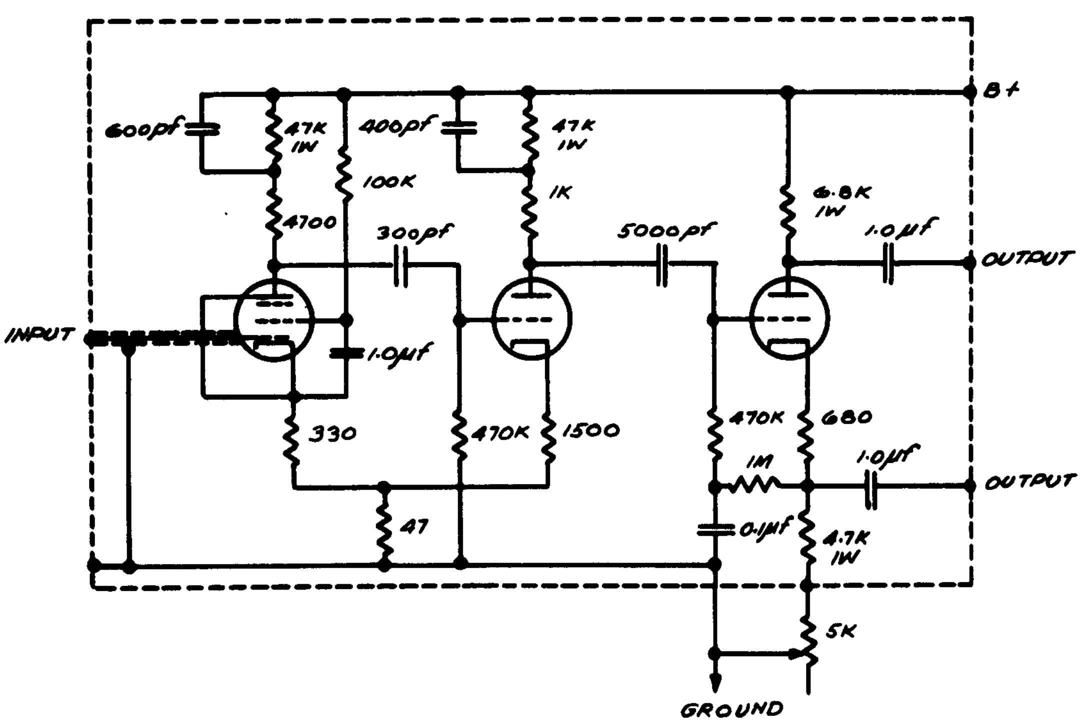
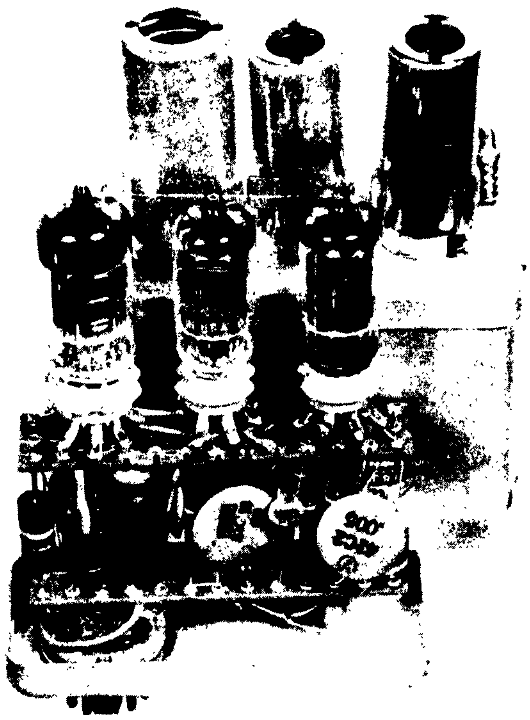
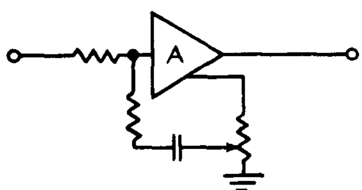


FIG.5 PHASE INVERTER





TYPICAL CIRCUITRY USING HIGH-GAIN AMPLIFIER

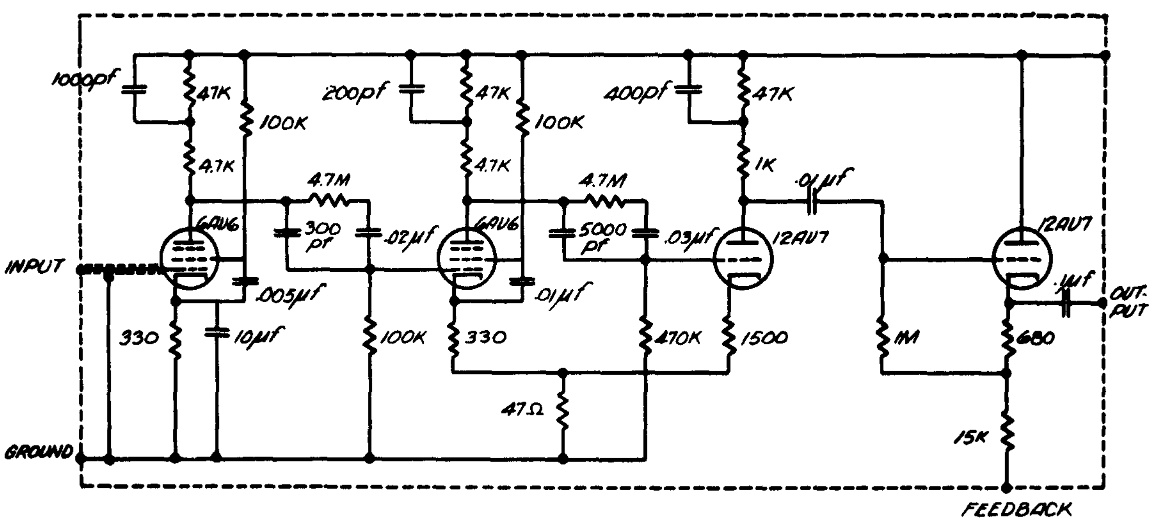
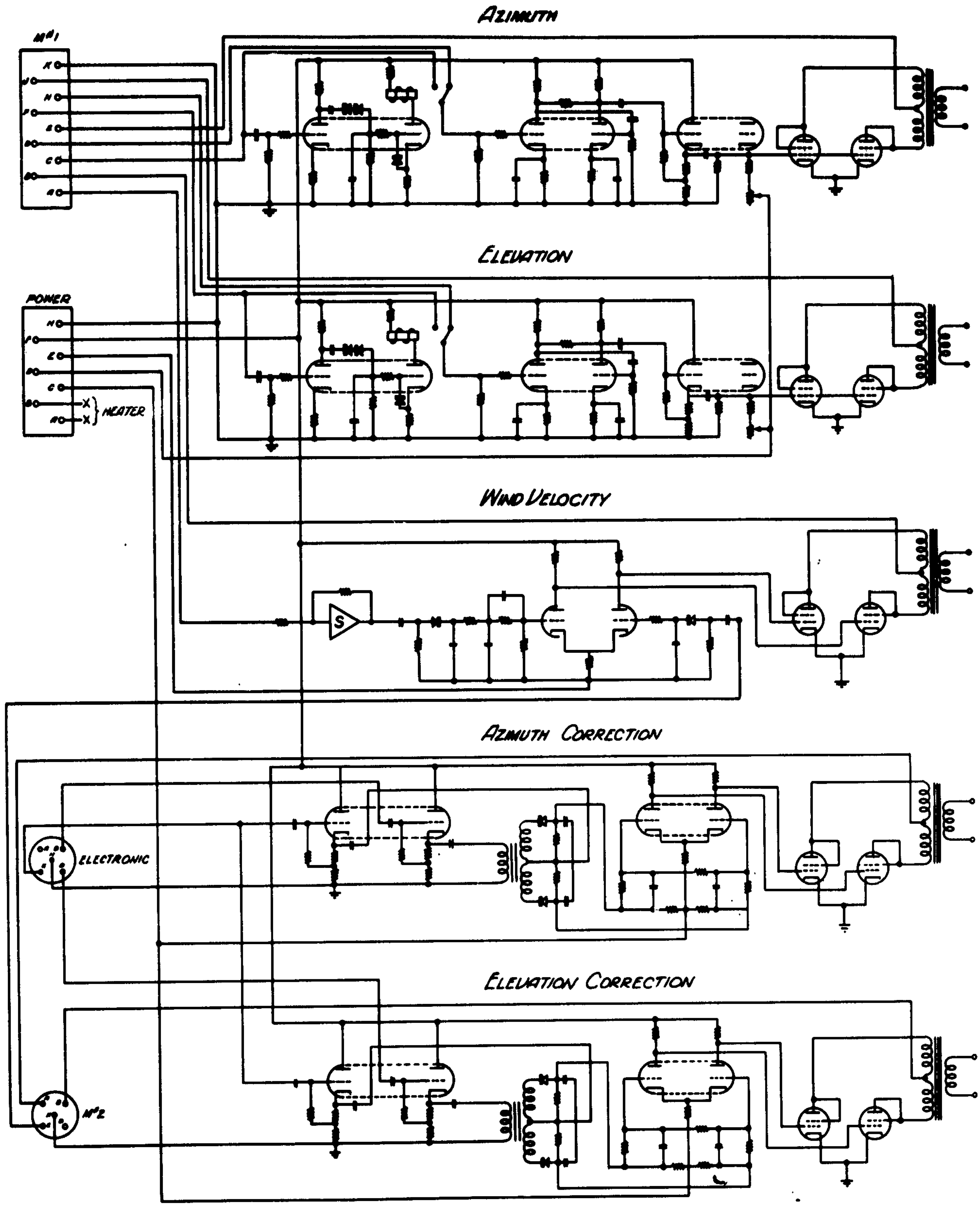


FIG. 6 HIGH GAIN AMPLIFIER

Five servo amplifiers are shown in Fig. 7; they are of three types. The first of the three types derives its error signal from 60 cps control transformers. The second type derives its error signal from the comparison of a constant voltage with the amplitude of a 3000 cps signal. The third type derives its error signal from the phase sensitive rectification of a 3000 cps signal.

The first type includes the azimuth and elevation servo amplifiers--the top two amplifiers in Fig. 7. The two amplifiers are identical so it will suffice to describe the azimuth servo amplifier. The two inputs, C and D, are derived from the coarse and fine control transformers respectively. The role of the servo system is to keep the shafts of the coarse and fine control transformers aligned with their input signals so that their output is zero. If the misalignment is large, the coarse input places itself into control over the fine input by means of a relay. This arrangement prevents ambiguity of alignment when the accuracy of the fine input must be utilized. The 60 cps signal that is chosen by the relay is amplified and applied to the grids of the driver tubes. The phase of the signal is determined by the sense of the misalignment and determines the direction of rotation of the servo motor.

The second type of servo amplifier is the center one in Fig. 7, the wind velocity servo amplifier. The input from terminal A of the M-1 connector is the composite 3000 cps signal resulting from the quadrature superposition of the two wind



SERVO AMPLIFIER PANEL FIG. 7

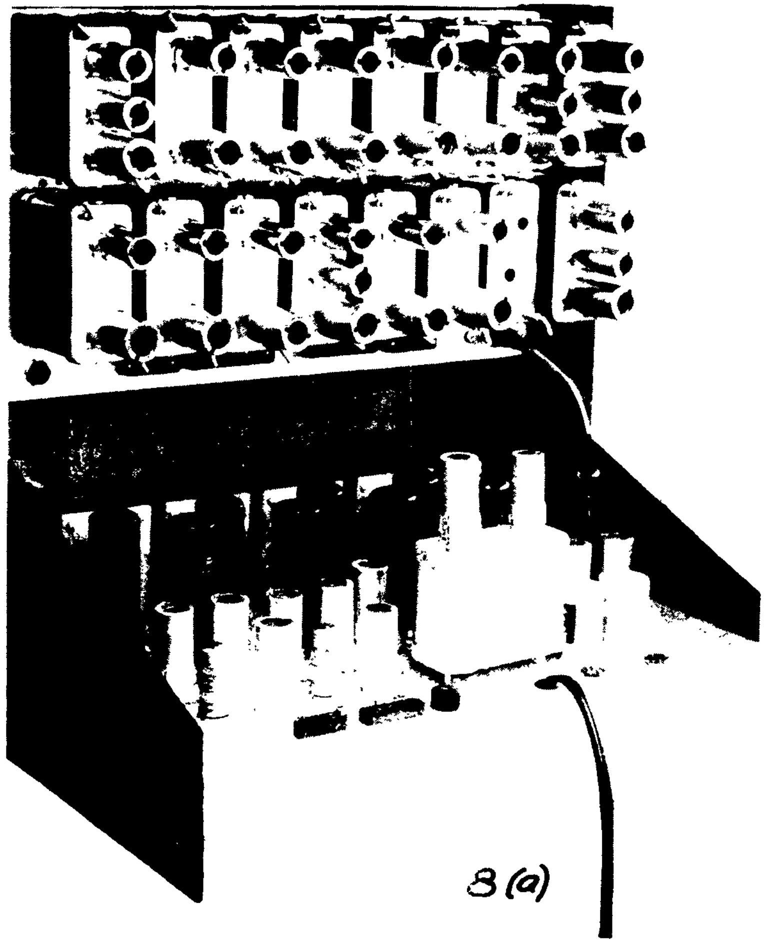
velocity inputs. The magnitude of the signal at terminal A is determined by the position of rotary potentiometers whose shaft position is determined by this servo system. The role of this servo system is to position the shaft continuously so that the amplitude of the signal at terminal A is very nearly a constant. This is accomplished by amplifying the voltage at A, rectifying it, and then comparing the result with a constant voltage. The difference is amplified to drive the servo motor in a direction that reduces this difference. For normalization purposes, the "constant" voltage compared with the rectified signal is the rectified output of the oscillator that powers the anemometer. The rectifying circuit for the signal contains a lead network that prevents oscillations in the servo system.

The third type of servo amplifier includes the elevation and azimuth correction amplifiers at the bottom of Fig. 7. The role of each of these two servo systems is to equate to zero the sum of the inputs to a high-gain amplifier by rotating the potentiometer pick-offs as inferred by Fig. 2.

The input to the azimuth correction amplifier (terminal B of the electronic connector in Fig. 7) is phase-sensitive rectified to produce a D. C. voltage that is amplified and used to control the servo motor. The phase sensitive rectification is made in reference to the 3000 cps from the oscillator introduced at terminal E and determines the sense of rotation of the servo motor that reduces the input signal of the servo amplifier. The elevation correction servo system differs from the azimuth correction servo system only in the quantities whose sum is being equated to zero. The electronic panel is shown above the servo amplifier panel in Fig. 8a as they are mounted in the computer.

The Electromechanical System

The electromechanical system of the computer includes the servo motors, control transformers, torque differential transmitters, gear trains, potentiometers, and additional hardware. The entire system has been assembled in sections, but the completion of the unit as a whole awaits the delivery of four servo motors. This section of the experimental computer was assembled with standard components mounted upon a perforated plate. Fig. 8b shows one of the electromechanical units as it will be mounted in the computer.


8(a)


8(b)

FIG. 8(a) SERVO AMPLIFIERS & ELECTRONIC PANEL
FIG. 8(b) ELECTROMECHANICAL UNIT

PART II

Introduction

Statistical information presented in previous reports, Refs. 1 and 2, on the effect of wind on LOKI burnout deviation has been based on data collected at the University of Michigan by Sherlock and Stout, using wind profiles extending to 200 feet. Since only 50% of the final deviation is due to wind in the first 200 feet, it was found desirable to conduct studies extending the profiles to 1000 feet, thereby obtaining 90% of the effect.

For this purpose a balloon-borne hot wire anemometer system, Ref. 3, was developed and measurements were made at both El Mirage Airport in the Mojave Desert, and at White Sands Proving Ground. Data collected in this project were reduced and analyzed by Messrs. R. E. Kerr, Jr., and J. B. Powers of the Aerophysics Research Foundation using IBM equipment.

Data Reduction and Analysis

Balloon sounding records in the form of oscillographic traces were reduced and entered onto IBM punch cards. For each run burnout deviations were computed by integrating the wind observations weighted with the influence function, as in Ref. 2. Correlation coefficients were computed of δ with the wind speed at each anemometer height and rolling time averages of 1, 2, 4, and 8 seconds. A total of 520 correlation coefficients was computed. The resulting values of the correlation coefficients were then grouped and distributed to determine the combinations of the averages and heights that would give the highest correlation coefficient.

Results

Table I shows the run number, number of observations in each run, mean wind speed for each channel, average value of δ and standard deviation of δ for each sample.

It is to be noted that with the wind structure as recorded, the average value of δ was generally quite low, and the error due to using the average δ for the run would, in 90% of the cases, have been less than 3 mils for all runs except for run 16. The extremely high wind-shear reported between 600' and 1000' for the first half of run 16 is doubtful and should not be accepted without corroborative evidence.

In view of the light winds and the large separation between adjacent readings, there is some doubt as to the value of the individual values of δ, although the low values of the standard deviation of δ suggest that representative values were obtained in spite of the low correlation probably existing between the wind speeds at adjacent anemometers.

The average wind profile for each run, as shown by Table I, is unusual in that only in three cases is the lowest wind reported at the lowest level. Ten cases have the minimum wind reported at 175' (Channel 4), 7 cases show the minimum wind at 300' (Channel 3) and 10 cases have the lowest wind at 600' (Channel 2).

Where a gap in the wind record showed on the tape, the run was divided into A and B sections as shown in Table I. The subdivision identification is not shown on subsequent tables but the runs are printed in the same order in each case.

TABLE I
MEAN WIND SPEEDS AND DEVIATIONS

Run #	No. of obs.	Average wind speed, ft/sec Channel No.					Deviation	
		1	2	3	4	5	$\bar{\delta}$	σ_{δ}
1-A	063	4.4	3.4	3.7	4.2	4.1	3.0	0.78
1-B	269	4.7	3.0	3.3	4.5	4.1	3.0	0.58
2	61	14.0	5.4	5.0	5.0	5.5	5.4	1.36
3-B	69	3.2	1.2	1.8	3.6	4.4	2.2	0.20
4	313	6.1	3.6	3.1	3.6	4.1	3.2	0.69
5-A	157	9.8	5.6	5.7	6.3	7.5	5.4	1.09
6	261	4.7	3.4	3.0	2.9	2.9	2.5	0.53
7-A	73	6.7	4.9	3.5	4.8	2.9	4.0	0.60
7-B	89	10.0	7.8	6.5	7.2	7.6	6.0	0.41
9-A	161	2.8	2.0	1.0	1.5	1.5	1.0	0.28
9-B	73	2.1	1.9	2.4	2.0	2.4	1.7	0.44
10-A	115	3.9	1.7	2.0	1.9	1.8	1.7	0.41
10-B	53	2.6	0.8	2.1	2.2	2.5	1.6	0.36
11-A	113	6.4	4.2	3.6	5.3	7.8	4.2	1.15
11-B	159	4.1	2.8	2.6	3.2	5.2	2.7	0.73
12	137	3.2	2.0	2.7	2.8	2.0	2.0	0.37
13-A	093	11.9	6.4	8.3	6.4	9.9	6.6	1.22
14	56	15.4	6.5	7.6	5.3	7.3	6.5	1.14
16	165	53.1	20.5	13.0	9.0	12.1	16.5	2.52
16	205	34.7	17.0	12.7	10.8	16.2	14.1	1.34
17-A	253	30.5	14.9	12.0	9.3	15.1	12.6	1.19
854	33	24.9	9.0	8.2	7.9	6.9	8.8	0.52
855	41	18.1	7.2	6.2	5.1	7.5	6.8	0.86
857	29	15.2	7.7	6.1	5.2	5.7	6.2	1.19
858	56	13.0	5.4	5.8	7.4	7.6	6.0	0.56

Height of annemometers:
Channel 1 - 1000'
2 - 600'
3 - 300'
4 - 175'
5 - 75'

$\bar{\delta}$ = average value of δ

σ_{δ} = sample standard deviation of δ

Minimum value of wind underscored

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Table II shows the distribution of the standard error of estimate of δ, corrected to include 90% of the cases ($S_{\delta 90}$).

Table III shows the distribution of computed correlation coefficients, grouped into classes of 0.10. The few negative values were all grouped together in a single class. In this table and all following discussions of "r", the correlation coefficient, it is to be understood that the correlation was calculated for each run between the computed value of δ for that run and the wind for each run, for each channel for each of the rolling time averages used, 1, 2, 4, and 8 consecutive observations. A total of 520 separate values of "r" were computed. The total for each class is shown as the first part of Table V.

Table IV shows the distribution of δ for each run divided into classes of 2.0 mils. The part runs marked with an asterisk contained some doubtful calculations and were not included in any of the other tables.

Table V shows the scatter of the slope of the regression lines, computed for each run, for each height and time average combination, but as in Tables I-IV, the distribution is shown only by runs, and not by further subdivisions.

Tables VI-XII show the distribution of the correlation coefficient for all cases together, and then grouped for each height and then for each height-time combination for all runs (Table VI); grouped for each time average and for each time-height combination, (Table VII); and finally grouped according to the average wind speed and distributed for each time-height combination (Tables VIII-XII inc.).

TABLE II
DISTRIBUTION OF S_{s90} BY 0.3 MILL CLASS INTERVALS FOR EACH RUN,
ALL TIME AND HEIGHTS TOGETHER

Run No.	Tot.	0.00 0.29	0.30 0.59	0.60 0.89	0.90 1.19	1.20 1.49	1.50 1.79	1.80 2.09	2.10 2.39	2.40 2.69	2.70 2.99	3.00 3.29	3.30 3.59	3.60 3.89	3.90 4.19	C..
All	520	5	131	141	52	57	67	38	9		4		7	1	8	[illegible]
001	20		8	8	4											0
001	20		3	13	4											0
002	20					3	4	7	6							0
003	20	5	15													0
004	20			8	12											0
005	20			8	4	2	6									0
006	20		2	18												0
007	20		6	14												0
007	20		16	4												0
009	20		20													0
009	20		8	12												0
010	20		14	6												0
010	20		20													0
011	20					11	9									0
011	20			5	12	3										0
012	20		19	1												0
013	20					5	15									0
014	20				3	13	1	3								0
016	20										4		7	1	8	0
016	20						4	13	3							0
017	20					1	13	6								0
017	20					1	12	7								0
654	20			20												0
655	20			2	8	10										0
657	20			4	3	8	3	2								0
658	20			18	2											0

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TABLE III

DISTRIBUTION OF CORRELATION COEFFICIENTS FOR EACH RUN, ALL TIMES AND HEIGHTS GROUPED

Run No.	Tot.	.00 0.09	.10 .19	.20 .29	.30 .39	.40 .49	.50 .59	.60 .69	.70 .79	.80 .89	.90 .99	Neg.	Check
01	20						1	3	2	8	6		0
01	20		2	2		4	8		2	2			0
02	20		1	1	6	3	2		4	3			0
03	20	1	3	2	4	4	3					3	0
04	20					2	9	4	2	3			0
05	20						8		4	5	3		0
06	20			1	5	2	2	3	7				0
07	20						4	3	7	6			0
07	20	1				1	5	9	1			3	0
09	20		2	4	3	2	5		4				0
09	20	3		2	1	3	4	2		4		1	0
10	20				4	4	7	1	4				0
10	20	3	1	3	2		1	6	4				0
11	20					1	6	8	5				0
11	20	1	1		1	2	4	6	3			2	0
12	20		1		5	6	5	1	1	1			0
13	20					1	9	6	4				0
14	20	1	1					3	11	2		2	0
16	20	4	1	2		1	6	1	4			1	0
16	20			2	3	10	1	4					0
17	20				3	7	2	8					0
17	20			1	4	5	7	3					0
54	20	2		1	4	1	8					4	0
55	20		2	3	1	2	5	3	3	1			0
57	20			1	1		2	2	7	3	4		0
58	20			2	3	6	3	6					0

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TABLE IV

DISTRIBUTION OF δ ON [illegible].A.I. BALLOON SOUNDINGS

		δ Grouped by Classes of 2 mils														
Run No.	Total	0.0 1.9	2.0 3.9	4.0 5.9	6.0 7.9	8.0 9.9	10.0 11.9	12.0 13.9	14.0 15.9	16.0 17.9	18.0 19.9	20.0 21.9	22.0 23.9	24.0 25.9	26.0 27.9	Check
		1	[illegible]	8												
[illegible]	[illegible]	[illegible]	[illegible]	12												[illegible]
[illegible]			[illegible]	39	15	4										0
*[illegible]	[illegible]	24	159	48	9											[illegible]
[illegible]	76	15	61													[illegible]
004	[illegible]	1	255	[illegible]												0
[illegible]	[illegible]		20	86	58											0
*[illegible]	3		42	[illegible]	5											[illegible]
006	[illegible]	29	226	4												[illegible]
007	80		45	35												[illegible]
007	96			57	39											[illegible]
[illegible]	[illegible]	160	8													[illegible]
009	80	61	[illegible]													[illegible]
010	[illegible]	92	39													[illegible]
010	[illegible]	51	9													
011	120		56	52	12											[illegible]
011	[illegible]	37	125	4												0
012	144	30	64													0
013	100		6	23	59	12										0
*013	124			78	45	1										0
014	63			28	28	7										0
016	172				1		3	16	[illegible]	58	16	11	5		1	[illegible]
015	212						22	74	103	12	1					0
017	260					6	77	143	34							0
017	280					1	21	126	123	9						0
654	40				1	33	6									0
655	48			11	32	5										0
657	36		1	11	24											[illegible]
658	63			29	34											0

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TABLE V

DISTRIBUTION OF SLOPES OF REGRESSION LINES BY CLASSES OF 0.1 MILLS PER FT. PER SEC

Run No.	Tot.	All Neg	.00 .09	.10 .19	.20 .29	.30 .39	.40 .49	.50 .59	.60 .69	.70 .79	.80 .89	.90 .99	Above 1.00	Ck.
All	520	16	23	96	161	101	48	37	18	9	4	3	4	0
001	20					4	4	2	3	1	1	2	3	0
001	20			6	6	3	1	3	1					0
002	20			8	1	5	2	2	2					0
003	20	3	3	11	3									0
004	20			4	3	8	1	4						0
005	20					5	6	5		2	1	1		0
006	20			2	10	8								0
007	20				2	5	6	6	1					0
007	20	3	1		8	5	2	1						0
009	20			7	10	3								0
009	20	1	3	3	9	1	1	1	1					0
010	20			2	12	5	1							0
010	20		4	7	2	5	2							0
011	20			1	8	5	2			4				0
011	20	2	2	4	3	9								0
012	20		1	6	13									0
013	20				9	3	4	2	2					0
014	20	2	1	1	3	4	2	3	2	1	1			0
015	20	1	3	8	2	2	2	2						0
016	20			6	9	3	2							0
017	20			2	11	7								0
017	20			6	8	4	1	1						0
854	20	4	4	4	7	1								0
855	20		1	6	4	2	7							0
857	20			1	2	2	2	4	6	1	1		1	0
858	20			1	16	2		1						0

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TABLE VI

DISTRIBUTION OF "r" by CLASS INTERVALS of 0.10

All [illegible]

Height	Tot.	.00 .09	.10 .19	.20 .29	.30 .39	.40 .49	[illegible]	.60 .69	.70 .79	.80 .89	.90 .99	Neg.	
	520	16	15	27	50	67	117	82	79	38	13	16	0
	EACH HEIGHT FOR ALL TIME AVERAGES												
1	104	2	3	7	7	9	12	21	31	10	3	4	0
2	104	4	4	5	9	13	31	17	13	6		2	0
3	104	2	3	7	11	16	24	16	13	4	2	6	0
4	104	3	2	4	13	16	26	14	14	10	1	1	0
5	104	5	3	4	15	13	24	14	8	6	7	3	0
Time Avg. Height	EACH HEIGHT, EACH TIME AVERAGE												
11	26	1		2	1	1	3	5	8	5			0
12	26			3		2	2	5	10	2	1	1	0
14	26	1	1	1		3	3	6	7	2	1	1	0
18	26		2	1	1	3	4	5	5	1	1	2	0
21	26	1	1		1	3	8	4	5	1			0
22	26	1	2	1	1	2	9	5	3	2			0
24	26	1		2	2	1	10	4	3	2		1	0
29	26	1	1	2	3	7	4	4	2	1		1	0
31	26	1		2	2	5	8	3	6			1	0
32	26			2	3	4	5	5	3	2		2	0
34	26		1	1	4	5	5	4	2	1	1	2	0
38	25	1	2	2	2	4	6	4	2	1	1	1	0
41	26	1		1	1	2	9	5	4	3			0
42	26	1		1	2	5	7	3	3	3	1		0
44	25	1	1	1	3	6	5	2	4	3			0
48	26		1	1	7	3	5	4	3	1		1	0
51	26	1	1	1	3	3	8	4	1	3	1		0
52	25	2		1	4	3	7	3	2	2	2		0
54	26	1	1		3	5	6	4	2	1	2	1	0
58	26	1	1	2	5	2	3	3	3	2	2	2	0

TABLE VII

DISTRIBUTION OF "r" BY TIME AVERAGES FOR ALL HEIGHTS

Time	Tot.	.00 .09	.10 .19	.20 .29	.30 .39	.40 .49	.50 .59	.60 .69	.70 .79	.80 .89	.90 .99	Neg.	
1	130	5	2	6	10	12	36	21	24	12	1	1	0
2	130	4	2	8	10	16	30	21	21	11	4	3	0
4	130	4	4	5	12	20	29	20	18	9	4	5	0
8	130	3	7	8	18	19	22	20	16	6	4	7	0

EACH TIME AVERAGE, EACH HEIGHT

Time / Height													
11	25	1		2	1	1	3	5	8	5			0
21	26	1	1		3	3	8	4	5	1			0
31	26	1		2	2	3	8	3	6			1	0
41	25	1		1	1	2	9	5	4	3			0
51	26	1	1	1	3	3	8	4	1	3	1		0
12	26			3		2	2	5	10	2	1	1	0
22	26	1	2	1	1	2	9	5	3	2			0
32	26			2	3	4	5	5	3	2		2	0
42	25	1		1	2	5	7	3	3	3	1		0
52	26	2		1	4	3	7	3	2	2	2		0
14	25	1	1	1		3	3	6	7	2	1	1	0
24	26	1		2	2	1	10	4	3	2		1	0
34	25		1	1	4	5	5	4	2	1	1	2	0
44	26	1	1	1	3	6	5	2	4	3			0
54	26	1	1		3	5	6	4	2	1	2	1	0
18	26		2	1	1	3	4	5	6	1	1	2	0
28	25	1	1	2	3	7	4	4	2	1		1	0
38	26	1	2	2	2	4	6	4	2	1	1	1	0
48	26		1	1	7	3	5	4	3	1		1	0
58	26	1	1	2	5	2	3	3	3	2	2	2	0

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TABLE VIII

DISTRIBUTION OF "r" ACCORDING TO AVERAGE WIND FOR
EACH HEIGHT AND TIME AVERAGE

height/time		Tot.	.00 .09	.10 .19	.20 .29	.30 .39	.49 .49	.50 .59	.60 .69	.70 .79	.80 .89	.90 .99	Neg.	Ck.
Wind		26	1		2	1	1	3	5	8	5			0
0.0 - 4.9	11	10			2			1		4	3			0
5.0 - 9.9	11	4						2		2				0
10.0 -19.9	11	7	1						3	1	2			0
20.0	11	5				1	1		2	1				0
		26			3		2	2	5	10	2	1	1	0
0.0 - 4.9	12	10			2		1			5	1	1		0
5.0 - 9.9	12	4						2		2				0
10.0 -19.9	12	7							3	2	1		1	0
20.0	12	5			1		1		2	1				0
		26	1	1	1		3	3	6	7	2	1	1	0
0.0 - 4.9	14	10		1	1		1		1	4	1	1		0
5.0 - 9.9	14	5						2	1	1			1	0
10.0 -19.9	14	6					1	1	2	1	1			0
20.0	14	5	1				1		2	1				0
		26		2	1	1	3	4	5	6	1	1	2	0
0.0 - 4.9	18	10		1		1	1	1	1	3	1	1		0
5.0 - 9.9	18	5					1	2		1			1	0
10.0 19.9	18	6		1	1		1		2	1				0
20.0	18	5						1	2	1			1	0

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TABLE IX

DISTRIBUTION OF "r" ACCORDING TO AVERAGE WIND FOR EACH HEIGHT AND TIME AVERAGE

height/time		Tot.	.00 .09	.10 .19	.20 .29	.30 .39	.40 .49	.50 .59	.60 .69	.70 .79	.80 .89	.90 .99	Neg.	Chk.
Wind		26	1	1		3	3	8	4	5	1			0
0.0 - 4.9	21	13	1			1	2	4	2	2	1			0
5.0 - 9.9	21	9		1		1		3	1	3				0
10.0 -14.9	21	1							1					0
15.0	21	3				1	1	1						0

		26	1	2	1	1	2	9	5	3	2			0
0.0 - 4.9	22	13		2			1	5	2	1	2			0
5.0 - 9.9	22	9	1		1			3	2	2				0
10.0 -14.9	22	1							1					0
15.0	22	3				1	1	1						0

		26	1		2	2	1	10	4	3	2		1	0
0.0 - 4.9	24	13	1		1	1		5	2	1	2			0
5.0 - 9.9	24	9			1			4	1	2			1	0
10.0 -14.9	24	1							1					0
15.0	24	3				1	1	1						0

		26	1	1	2	3	7	4	4	2	1		1	0
0.0 - 4.9	28	13	1		1	1	4	2	2	1	1			0
5.0 - 9.9	28	9		1		2	1	2	1	1			1	0
10.0 -14.9	28	1							1					0
15.0	28	3			1		2							0

TABLE X

DISTRIBUTION OF "r" ACCORDING TO AVERAGE WIND FOR EACH HEIGHT AND TIME AVERAGE

Wind	height/time	Tot.	.00 .09	.10 .19	.20 .29	.30 .39	.40 .49	.50 .59	.60 .69	.70 .79	.80 .89	.90 .99	Neg.	Chk.
		26	1		2	2	3	8	3	6			1	0
0.0 - 4.9	31	13	1		1	1		4	2	4				0
5.0 - 9.9	31	9			1		1	3	1	2			1	0
10.0 -14.9	31	4				1	2	1						0

		26			2	3	4	5	5	3	2		2	0
0.0 - 4.9	32	13				2	2	2	3	2	1		1	0
5.0 - 9.9	32	9			1	1		3	1	1	1		1	0
10.0 -14.9	32	4			1		2		1					0

		26		1	1	4	5	5	4	2	1	1	2	0
0.0 - 4.9	34	13		1		2	2	2	2	2	1		1	0
5.0 - 9.9	34	9				2	1	2	2			1	1	0
10.0 -14.9	34	4			1		2	1						0

		26	1	2	2	2	4	6	4	2	1	1	1	0
0.0 - 4.9	38	13		1	1	1	2	2	3	1	1		1	0
5.0 - 9.9	38	9	1	1	1		1	2	1	1		1		0
10.0 -14.9	38	4				1	1	2						0

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TABLE XI

DISTRIBUTION OF "r" ACCORDING TO AVERAGE WIND FOR EACH HEIGHT AND TIME AVERAGE

Wind	height/time	Tot.	.00 .09	.10 .19	.20 .29	.30 .39	.40 .49	.50 .59	.60 .69	.70 .79	.80 .89	.90 .99	Neg.	Chk.
		26	1		1	1	2	9	5	4	3			0
0.0 - 4.9	41	12			1	1	1	4	2	1	2			0
5.0 - 9.9	41	13	1				1	4	3	3	1			0
10.0 -14.9	41	1						1						0
		26	1		1	2	5	7	3	3	3	1		0
0.0 - 4.9	42	12			1	1	2	4	1	1	2			0
5.0 - 9.9	42	13	1			1	2	3	2	2	1	1		0
10.0 -14.9	42	1					1							0
		26	1	1	1	3	6	5	2	4	3			0
0.0 - 4.9	44	12		1	1	1	3	2	1	1	2			0
5.0 - 9.9	44	13	1			2	2	3	1	3	1			0
10.0 -14.9	44	1					1							0
		26		1	1	7	3	5	4	3	1		1	0
0.0 - 4.9	48	12		1	1	3	1	1	2	3				0
5.0 - 9.9	48	13				4	1	4	2		1		1	0
10.0 -14.9	48	1					1							0

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TABLE XII

DISTRIBUTION OF "r" ACCORDING TO AVERAGE WIND FOR EACH HEIGHT AND TIME AVERAGE

Wind	height/time	Tot.	.00 .09	.10 .19	.20 .29	.30 .39	.40 .49	.50 .59	.60 .69	.70 .79	.80 .89	.90 .99	Neg.	Chk.
		26	1	1	1	3	3	8	4	1	3	1		0
0.0 - 4.9	51	10	1			2	2	2	1		2			0
5.0 - 9.9	51	12		1		1		5	2	1	1	1		0
10.0-14.9	51	1			1									0
15.0	51	3					1	1	1					0
		26	2		1	4	3	7	3	2	2	2		0
0.0 - 4.9	52	10	1			3	1	2	1		1	1		0
5.0 - 9.9	52	12	1			1	1	4	1	2	1	1		0
10.0-14.9	52	1			1									0
15.0	52	3					1	1	1					0
		26	1	1		3	5	6	4	2	1	2	1	0
0.0 - 4.9	54	10	1			2	2	3		1		1		0
5.0 - 9.9	54	12				1	1	3	3	1	1	1	1	0
10.0-14.9	54	1		1										0
15.0	54	3					2		1					0
		26	1	1	2	5	2	3	3	3	2	2	2	0
0.0 - 4.9	58	10		1	1	2	1	1	1	1		1	1	0
5.0 - 9.9	58	12			1	2		1	2	2	2	1	1	0
10.0-14.9	58	1	1											0
15.0	58	3				1	1	1						0

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To determine whether the correlation coefficients were normally distributed, and whether any channel gave significantly better results, Figs. 1 and 2 were prepared. All time averages were included. Here the cumulative frequency of the "r's" were plotted on arithmetic probability paper. The approximation was made that all of the "r's" falling in a given class interval lay at the mid-point of that interval. Fig. 1 shows the plot for each channel separately. No significant difference is noted between channels 2, 3, 4, and 5. Only Channel 1 shows any departure from the overall distribution. This is further shown in Fig. 2 where the cumulative frequency for channel 1 is plotted alongside the cumulative frequency for all channels.

The improvement due to use of Channel 1 is readily explained by the fact that each channel was assigned equal weight in computing δ , so that the much higher winds recorded at Channel 1 played a predominating part in determining δ and unduly weighted the resulting "r".

To further examine combinations of time averages and height of reading to detect significant departure from the overall distribution, Table XIII was prepared tabulating the average values of "r" for each time and height combination; average for each time for all heights; average for each height for all times, and the average for the entire group of 520 correlation coefficients. These data, together with the variance of "Z" are displayed in Fig. 3.

In obtaining an average value of "r" for the various combinations, the "r's" were first linearized using Fisher's Z transformation.

Assuming that the sum of all times and channels gave the true distribution, the χ^2 test for significance was applied to the distribution of "r" computed for the individual channels.

This test showed that the Channel 1 average "r" of 0.64 was different from the overall average at the .999 level of significance. Channel 5, which gave the next highest average "r" was approaching significance at the 0.900 level, the significance of the other channels being intermediate.

TABLE XIII

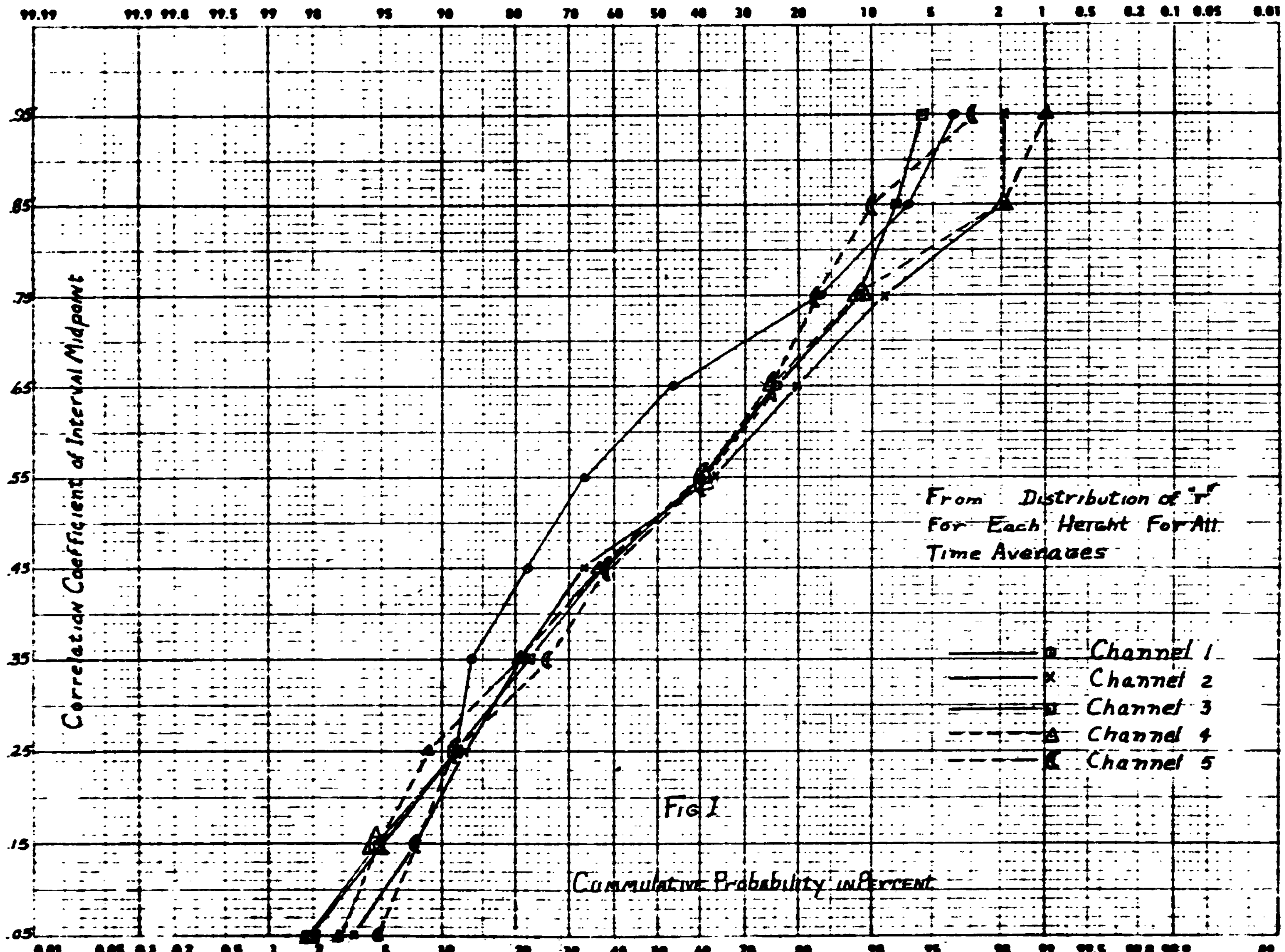
AVERAGE VALUES OF CORRELATION COEFFICIENTS
EACH TIME AND HEIGHT COMBINATION

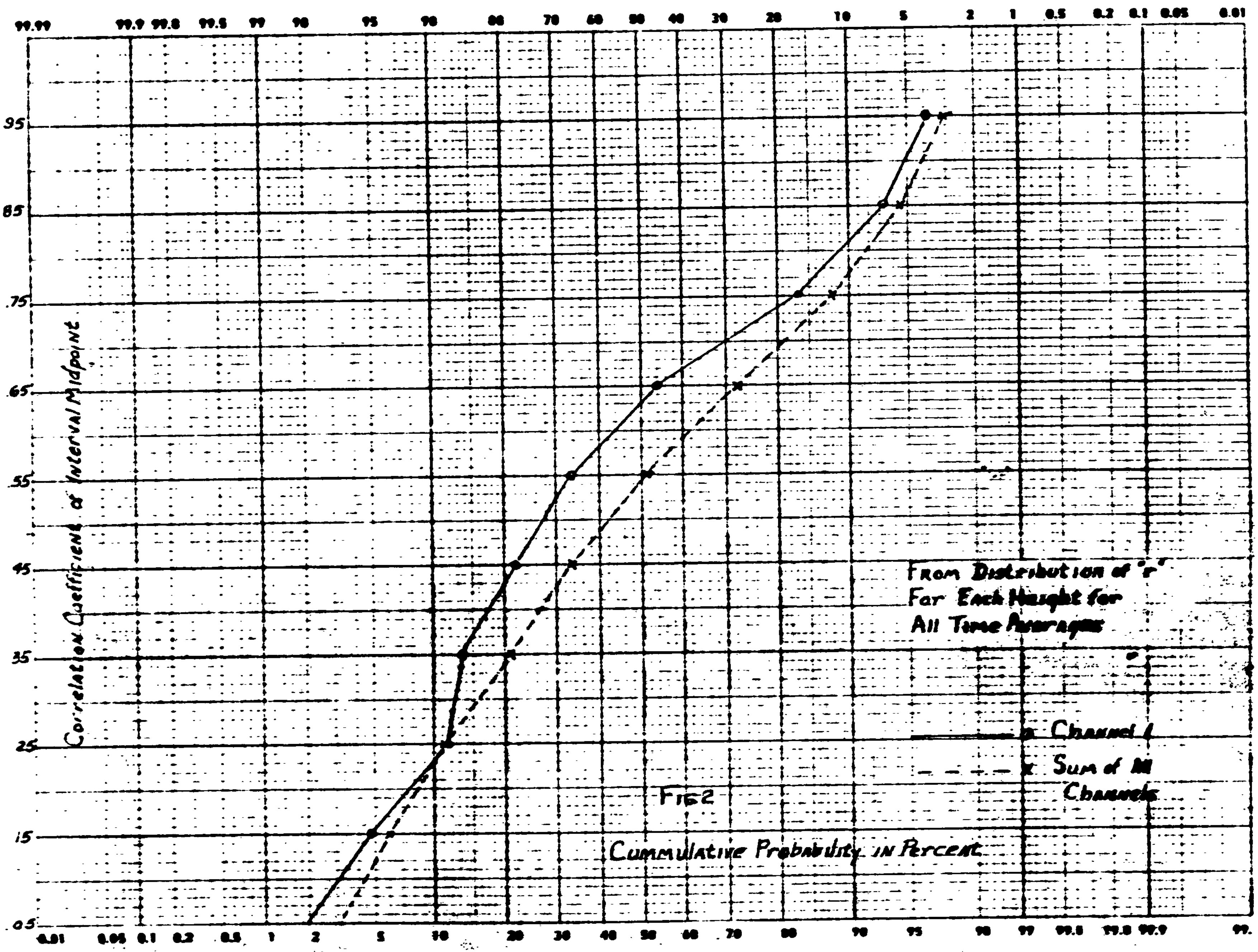
Channel	Time Average				
	1	2	4	8	Average
1	.67	.67	.64	.59	.64
2	.57	.57	.56	.49	.55
3	.54	.54	.53	.53	.53
4	.62	.61	.57	.51	.58
5	.59	.60	.58	.57	.59
Average	.60	.60	.58	.54	.58

Averages computed after linearizing using Fisher's Z transformation

$$Z = \frac{1}{2} \log e \frac{1 + r}{1 - r}$$

$$r = \tanh Z$$


From Distribution of "r"
For Each Height For All
Time Averages
Channel 1
Channel 2
Channel 3
Channel 4
Channel 5
Fig I
Cummulative Probability in Percent
Correlation Coefficient of Interval Midpoint


From Distribution of "r" For Each Height for All Time Averages
Channel 1
Sum of All Channels
Cummulative Probability in Percent
Correlation Coefficient of Interval Midpoint
FIG 2

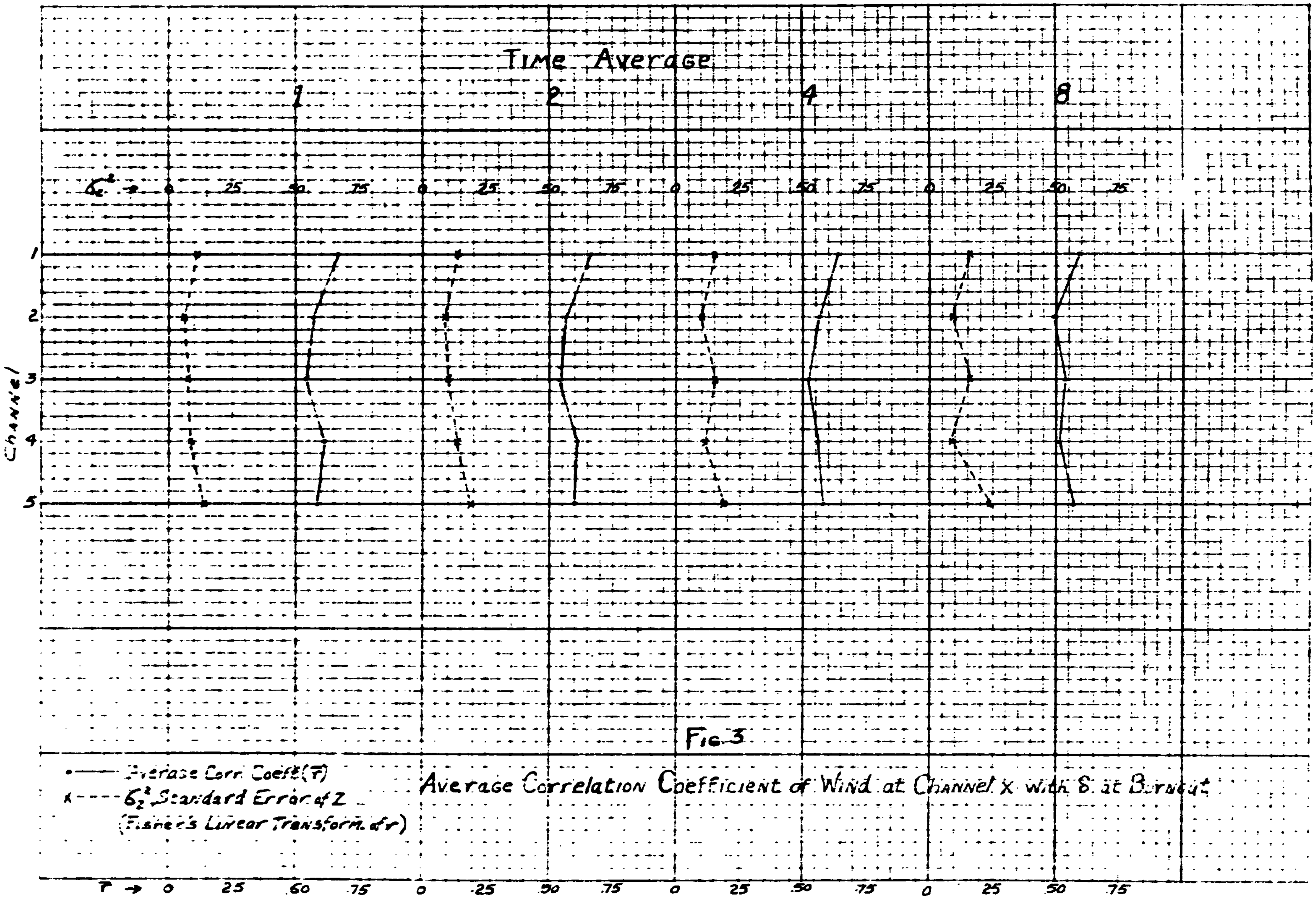


Fig 3

Average Correlation Coefficient of Wind at Channel x with δ at Burnout

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PART II

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3. See Ref. 3 above.